ABSTRACT

A liquid solidifies into a glass when the viscosity upon cooling becomes so large that molecular motion is effectively arrested on the relevant time scale. Based on the applicants combined theoretical and experimental research in the field, the proposed centre challenges the prevailing understanding of viscous liquids and the glass transition. This is done by focusing on four basic scientific questions. The following table gives the questions and briefly summarizes the standard answers and proposed alternatives:

SCIENTIFIC QUESTION	***STANDARD ANSWER***	***CONJECTURE***
A. Why is the relaxation time τ non-Arrhenius?	Because $\tau = \tau_0 \exp[A/TS_C]$ where S_C is the configurational entropy.	Because $\tau = \tau_0 \exp[VG_\infty / k_B T]$ where G_∞ is the instantaneous shear modulus.
B. What are the generic characteristics of alpha relaxation?	Time-temperature superposition is not fundamental. Linear alpha relaxation functions are usually well described by the so-called stretched exponential, corresponding to an $\omega^{-\beta}$ $(0 < \beta < 1)$ high-frequency decay of linear responses.	Beta processes at much lower frequencies than expected have confused the picture. Generic alpha relaxation obeys time-temperature superposition with universal high-frequency decay $\propto \omega^{-1/2}$, but non-universal loss peak width.
C. Is the beta process affected by the glass transition?	No.	Yes.
D. How many order parameters are needed for describing the glass transition?	More than one.	One.

The conjectures were arrived at from measurements on molecular liquids far below room temperature. The primary objective of the proposed research is to determine the validity and generality of these findings by investigating other classes of glass-forming liquids at other temperatures and under high pressure. The new classes of glass-formers to be studied include bioprotective sugars, oxide glasses, and polymers. Moreover, extensive computer simulations will be undertaken to investigate the validity of the four conjectures in simple model liquids.

A secondary objective is the development of experimental methods for measuring a complete set of thermo-visco-elastic linear response functions. This is necessary to answer question D, but the new experimental methods will be applicable to condensed matter in general and have value in and of itself.

Beside the potential long-time spin-off of basic research, the proposed centre will be utilized for educational purposes, covering an extra 8 Ph.D.-students, supervision of student projects in glass science at the master's and undergraduate levels, the creation of high school (gymnasium) student laboratory projects, and a web-page which popularises the research and offers small exercises in glass science.